Claims

What is claimed is:

1. A dielectric sensing method for detection and classification of chemical and biological materials comprising the steps of:

providing a resonator for receiving a sample;

detecting resonance patterns and identifying a shift in resonance frequency and a change of line width before and after introduction of the sample into said resonator; and

using said identified shift in resonance frequency and change of line width for determining a complex dielectric constant of the sample for the material detection and classification.

2. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 1 wherein the step of detecting resonance patterns includes the steps of generating said resonance patterns either as a function of sample concentration or as a function of excitation frequency for a given sample.

3. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 1 wherein the step of providing said resonator for receiving said sample includes the step of providing a microwave cavity resonator for receiving gas and solids samples; said cylindrical microwave cavity resonator having a cavity adjusting mechanism for adjusting a height of said cylindrical microwave cavity resonator.

4. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 3 further includes providing a gas inlet and a gas outlet in an end plate of said microwave cavity resonator for receiving gas samples.

5. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 3 further includes providing a sample holder on an end plate of said microwave cavity resonator located at a selected location for maximum magnetic field.

6. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 1 wherein the step of providing said resonator for receiving said sample includes the step of providing a parallel plate resonator for receiving liquid samples for soil contaminant measurement.

7. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 6 includes arranging said parallel plate resonator for RF frequencies in a range between 50 to 1000 MHz.

8. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 1 wherein the step of detecting resonance patterns and identifying said shift in resonance frequency and said change of line width before and after introduction of the sample into said resonator includes the step of selecting an excitation frequency corresponding to a resonance frequency of the sample.

9. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 1 wherein the step of detecting resonance patterns and identifying said shift in resonance frequency and said change of line width before and after introduction of the sample into said resonator includes the step of selecting an microwave excitation frequency for detecting resonance patterns.

10. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 9 wherein said shift in resonance frequency is represented by $\delta F = (f_0 - f_s)/ f_s$ where f_0 and f_s are the resonant frequencies before and after introduction of the sample into said resonator.

11. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 9 wherein said change in line width is represented by
$\delta T = ((1/ Q_{Us}) - (1/ Q_{U0}))$, where Q_{U0} and Q_{Us} represent unloaded quality factors before and after introduction of the sample into said resonator.

12. A dielectric sensing method for detection and classification of chemical and biological materials as recited in claim 1 wherein the step of detecting resonance patterns and identifying said shift in resonance frequency and said change of line width before and after introduction of the sample into said resonator includes the step of selecting an RF excitation frequency for detecting said resonance patterns.

13. A dielectric sensing apparatus for detection and classification of chemical and biological materials comprising:

a resonator for receiving a sample;

a vector network analyzer coupled to said resonator for detecting resonance patterns and identifying a shift in resonance frequency and a change of line width before and after introduction of the sample into said resonator; and

a computer coupled to said vector network analyzer for using said identified shift in resonance frequency and change of line width for determining a complex dielectric constant of the sample for the material detection and classification.

14. A dielectric sensing apparatus for detection and classification of chemical and biological materials as recited in claim 13 wherein said resonator includes a microwave cavity resonator for receiving gas and solids samples.

15. A dielectric sensing apparatus for detection and classification of chemical and biological materials as recited in claim 13 wherein said resonator includes a cylindrical microwave cavity resonator having a cavity adjusting mechanism for adjusting a height of said cylindrical microwave cavity resonator.

16. A dielectric sensing apparatus for detection and classification of chemical and biological materials as recited in claim 13 wherein said resonance patterns are detected using a selected excitation frequency corresponding to a resonance frequency of the sample.

17. A dielectric sensing apparatus for detection and classification of chemical and biological materials as recited in claim 14 wherein said resonance patterns are detected using an excitation frequency corresponding to an empty cavity resonance frequency.

18. A dielectric sensing apparatus for detection and classification of chemical and biological materials as recited in claim 13 wherein said resonator includes a parallel plate resonator for receiving liquid samples for soil contaminant measurement.

19. A dielectric sensing apparatus for detection and classification of chemical and biological materials as recited in claim 17 wherein said parallel plate resonator receives RF excitation frequencies in a range between 50 to 1000 MHz.

20. A dielectric sensing apparatus for detection and classification of chemical and biological materials as recited in claim 13 wherein said resonance patterns are generated either as a function of sample concentration or as a function of excitation frequency for a given sample.